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The Application of Computer Adaptive Test Using Expert System in E-Learning

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ABSTRACT

Higher education graduates must have competency abilities in accordance with the learning outcomes that have been formulated equivalent to the Indonesian National Qualifications Framework (KKNI) which is a problem that must be resolved at this time. According to the KKNI occupation map, a student must have skills in accordance with course learning outcomes. Where graduates in tertiary institutions are still difficult to compete in the world of work because they are not supported by the skills and competencies they got after graduating. One solution that can be used to help tertiary institutions in seeing student competencies that are easily accessible at affordable costs is through e-learning. The purpose of this research is to model the learning evaluation process by conducting online exams in the form of Computerized Adaptive Testing (CAT) using an expert system in the e-learning application, where test items are analyzed based on the level of difficulty, distinction, and function of the distractor. The procedure for selecting a test item for the diagnosis of thinking skills is based on the revised concept of Bloom's cognitive taxonomy and the expert system uses the rule-based method that provides a solution to the problem of measuring student competency abilities. The research can measure the competence of students by providing test questions that have a difficulty level. The CAT application can administer the items to be tested, grouped based on 3 levels of the test taker's thinking ability, namely questions with low, medium and high levels. Furthermore, the item calibration is entered into the CAT-assisted database using a rule-based expert system. Another facility of the CAT application is that it can display randomized questions by combining the Multistage Testing (MST) model in e-learning.

Keywords: Skill and Competence, Computerized Adaptive Testing, E-Learning, Expert System, Rules Basis

1. Introduction

Higher education as a producer of educated human resources needs to measure its graduates, whether the graduates produced have the same ability as the learning outcomes formulated in the Indonesian National Qualifications Framework (KKNI). As a national agreement, it is stipulated that graduates of the undergraduate program must at least have an ability that is equivalent to the learning outcomes formulated at the 6 KKNI level, Masters equivalent at level 8, and a doctorate equivalent at level 9 (Kominfo, 2018)[1]. The challenge for higher education in Indonesia is to provide more computer-based education services in an e-

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learning system and student assessment so that the ability of learning outcomes can be measured.The importance of conducting assessments in education [37-42].

In testing students' test ability and giving test questions by the lecturer, computer-based testing has not been carried out, which raises the problem of determining the difficulty level of test items that should be entered into a personalized test for each Bloom's Taxonomy with the abilities of the students being tested. Most educators use Classical Test Theory (CTT) in assessing test results that have the attributes of scoring the observations by the sum of the actual scores and the error scores [2]. The results of the study state that the Item Response Theory (IRT) is based on the parameters of the difficulty level of the items, the distinction power and the trickery function where the characteristics of the items will remain the same and do not depend on test participants in answering the questions given [3] [4] [5].

The assessment of learning outcomes that have been passed by students is a process that is actually not easy and not a simple thing to do. Educators need to make a diagnosis before making an assessment [6] [7] [8]. The concept of the development of assessment in learning in the era of digital literacy as it is currently popular is the diagnosis of thinking skills carried out by administering a number of items by means of tests assisted by information and communication technology, namely Computer Adaptive Test or Computer Based Testing (CBT) [9]. The diagnosis of an ability is an examination of students' thinking abilities which is carried out by educators based on the results of the test (question response) to reveal the mastery of aspects of thinking skills [10] [11].

Diagnosis of thinking skills is very useful for educators in grouping or mapping students' cognitive abilities and being able to find out their weaknesses and strengths so that it will motivate students to be more diligent in studying [12]. Philipp et al., [13] and Tu et al., [14] stated that cognitive diagnosis is a tool to support assessment to evaluate learning outcomes. Diagnosis of the ability of students is very important in accordance with what was stated by [15] [16] that the diagnosis of the ability of the knowledge aspect is the basis for supporting assessment of learning outcomes. By making a diagnosis, educators will get information and explanation of the abilities that have been mastered and are not yet known by students on the material or subject that is presented in learning.

Various studies on diagnosing thinking skills with the help of information and communication technology such as Computer Adaptive Test (CAT) or Computer Based Testing (CBT) have been carried out. By using a computer-based system, where the test results can be immediately known in real time, the items displayed can adjust the material and subject based on the level of thinking ability [11] [14] [17] [18]. Where information and communication technology has been widely used by educators in carrying out the assessment process. Computer assisted exam administration with multiple choice question types such as CBT and E-Assessment. The advantage of multiple choice questions with 4 answer choices has high objectivity, can measure various levels of thinking skills, items can be analyzed qualitatively or quantitatively, questions can be easily randomized and the results can be immediately known to students.

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The Computer Adaptive Test (CAT) has several problems such as question calibration, item safety, the rules for selecting the initial questions displayed, the random item model, the scoring method, the criteria for terminating the questions and administering the displayed items [19] [20] [21] [22]. Calibration questions are grouped into questions with easy, medium and difficult levels and the answers are entered into a computer-assisted database, where the questions displayed are randomized and have successfully combined the Multistage Testing (MST) 1-2-4 model with the CAT model from the research results of Wang et al., [23].

Based on preliminary observations and analysis of the weaknesses of the CAT test model that the researcher has built previously, it is very interesting to develop the diagnostic test model further with a combination of Bloom's cognitive taxonomy revised concept and expert systems using an if-then rule-based method approach. Expert systems that have been used in answering problems to develop test items are proposed and carried out by [24] [25]. The items are written and developed based on the expertise experience of the lecturer or the team of lecturers [26] [27].

The concept of an expert system with a rule-based method can make it easier to determine the estimation of a certain object's ability more effectively and efficiently. Research by Liu et al., [28] state that everyone has a different level of thinking ability to find out this if-then rule-based method the expert system can determine. The CAT model uses a rule-based expert system with the revised concept of Bloom's Taxonomy cognitive theory is believed to be able to improve the quality standards of assessment so that gaps can be minimized.

Another study [29] has demonstrated a personalized and adaptive electronic assessment using Bloom's revised cognitive theory of Taxonomy in shaping a dynamic test item selection test. Diagnosis of thinking skills can be a strong basis as support before deciding whether to pass or fail students according to tracing of completeness of the material or subject. The combination of the concept of revised cognitive theory from Bloom's Taxonomy and expert systems is assumed to be very appropriate to do as an innovation towards advances in education in tertiary institutions in supporting a quality assessment system.

The CAT application in E-Learning uses a rule-based expert system with a forward chaining engine offering confidence that diagnosing thinking skills will be able to improve quality standards for assessing student competency capabilities so that existing gaps can be minimized. A diagnosis of thinking ability can be a strong basis for support before deciding whether to pass or fail students in certain courses. Diagnosis of thinking skills can be a strong basis for support before deciding whether to pass or fail students in certain courses or subjects. Therefore, the CAT application using an expert system is very feasible and important to develop. The advice or suggestion will be given as the output of the CAT application using a rule-based expert system in e-learning on the thinking skills of each student.

2. Research Method

2.1 Related Study

The use of expert systems lies in the use of methods and techniques in forming knowledge representations and their application of expert system development for educational purposes involving new and intelligent techniques to provide adaptive electronic assessments and personalized with Bloom's Taxonomy cognitive theory. Expert systems are included in

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artificial intelligence that can carry out tests with tracing techniques and knowledge-based expert subjectivity [29], where the observations are imprecise and unclear such as determining student knowledge and performance, which are often dependent and reflected through things that cannot be observed and measured directly [30].

The use of a rule-based system in selecting test items to assess student knowledge is to determine the number and level of difficulty of the items at each cognitive theory level from Bloom's Revised Taxonomy (RTB) [29]. Thus, the use of a rule-based expert system in e-learning is to deliver different test items to students. Figure 1 is the logical architecture of the system which combines the framework in two web-based tutoring systems with the aim of building a student-centered learning experience [29].

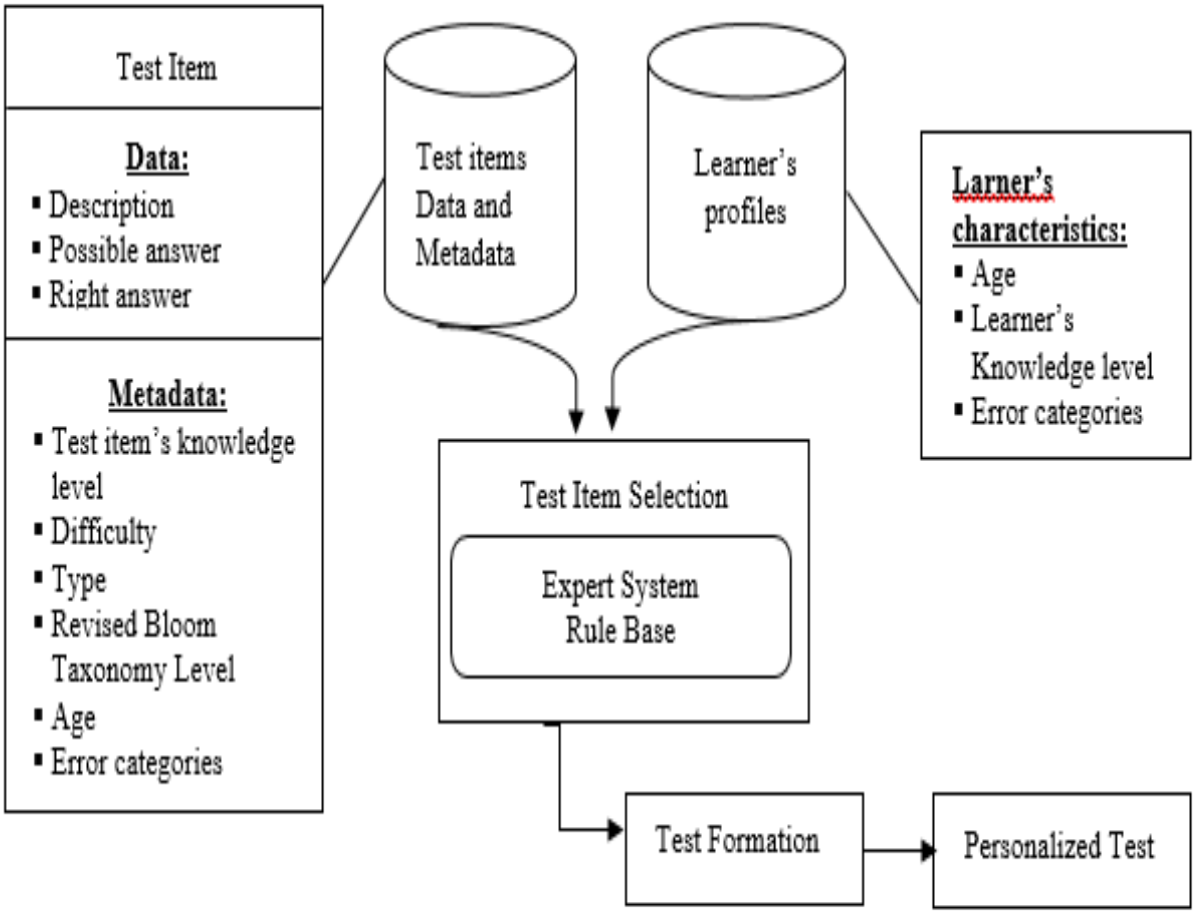

Figure 1. The Logical Architecture of the CAT Application Framework

In Figure 1, the analysis of the rule base for the expert system is to determine the assumptions of the ability of the test takers to be the same, to establish rules for scrambling questions, to set rules for the first and subsequent items to the high level to make suggestions or advice. While the question administration model that combines the 1-2-4 Multistage Testing (MST) model with the Computer Adaptive Test (CAT) model is illustrated in Figure 2.

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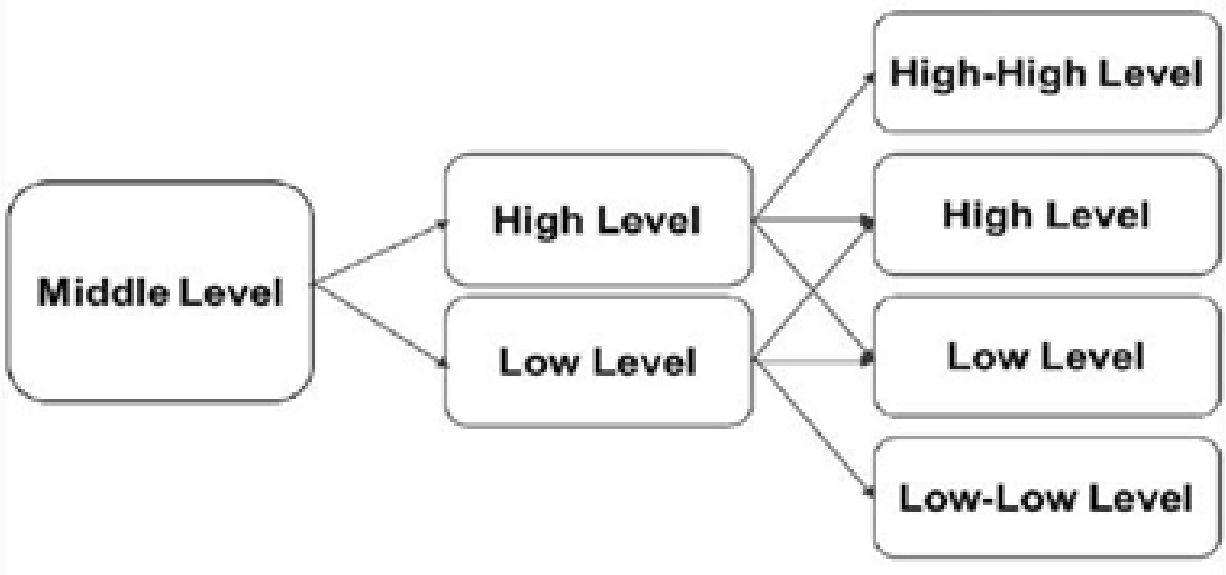

Figure 2. Model of Administration of MST 1-2-4 [23]

The administration of the test items is adjusted to the cognitive concept of Bloom's Taxonomy, which states that the classification of thinking abilities starts from the lowest level to the highest level. In the CAT application that was studied, all students who took the test were assumed to have the same thinking ability, so that linearly the initial questions displayed started from the lowest level to the highest level. This is in accordance with the suggestion put forward by [8] [31] [32] that the easy questions to be given at the beginning of the test will be able to make the examinees not get bored quickly to answer the questions. If the initial question given is a matter of higher order thinking skills, it will make the test taker frustrated more quickly.

2.2. CAT Application Development Structure

The flow chart of the computer assisted test system is illustrated in Figure 3.

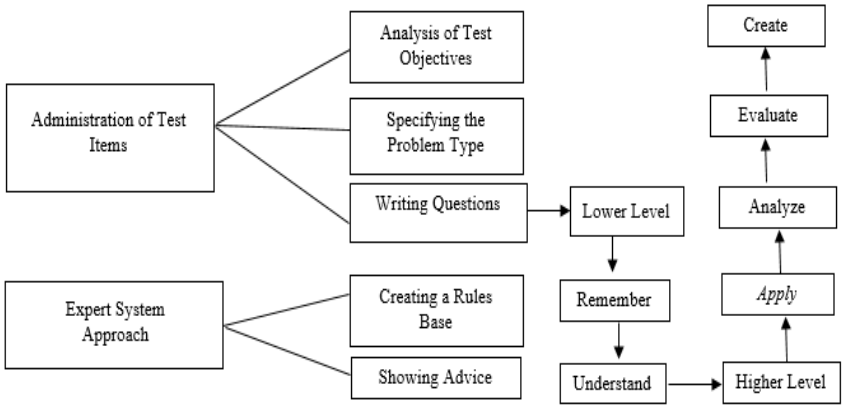

Figure 3. Development of a CAT Application Model using an Expert System

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The administration of the test items was adjusted to Bloom's cognitive taxonomy concept, which states that the classification of thinking abilities starts from the lowest level to the highest level. In the CAT application model using the proposed expert system, all test takers are assumed to have the same thinking ability, so that linearly, the initial questions displayed start from the lowest level to the highest level. This is in accordance with the suggestions put forward [33] [34] [35] [36] that the easy questions given at the beginning will make test takers not get bored quickly to answer questions. If the initial question given is a matter of higher order thinking skills, it will make the test taker frustrated more quickly. The results of the research show that the logic of decision making is described in the form of if-then-rules, so that a complex system can be built by combining many rules by involving the identification of the right variables [37].

3. Results and Discussion

3.1 System Analysis

System requirements specifications are shown in the use case diagram which is illustrated in Figure 4 which shows the relationship between actors and CAT applications. In the use case diagram, there are 3 actors involved in the CAT application using an expert system, namely Administrators, Lecturers and Students. Administrators can create user accounts, manage question data, lecturer data, student data, and verify the questions. In addition, administrators and users can view test results and solutions.

The questions in the CAT application are grouped into 3 levels, namely low level, medium level and high level. By using the Expert System, the application is set to select and present items at each step according to the results of the student's ability, so that students with a high level of ability will get more difficult items than students with low ability levels. On the other hand, students who have a low level of ability will get the items more easily than students who have a high level of ability.

With the existence of an expert system in the Computer Adaptive Test (CAT) application, the individual intelligence abilities of students at each step they pass will be guessed, the level of difficulty of the items will be sorted. Furthermore, by tracing the results obtained by students, the results will be directed to questions according to the scores obtained by the student, if the student answers correctly, many applications will provide a set of more difficult questions. Conversely, if the students answer a lot of mistakes, the application will be given a set of easier questions, and so on, this process is repeated until the test is stopped and the student's intelligence level is estimated.

In the search for questions using the forward chaining method on the expert system which is useful for measuring the level of student ability. Where this value will be the range in the expert system to determine at which level the next question will appear. The rule base used by researchers is the best-first seach search or tracking method.

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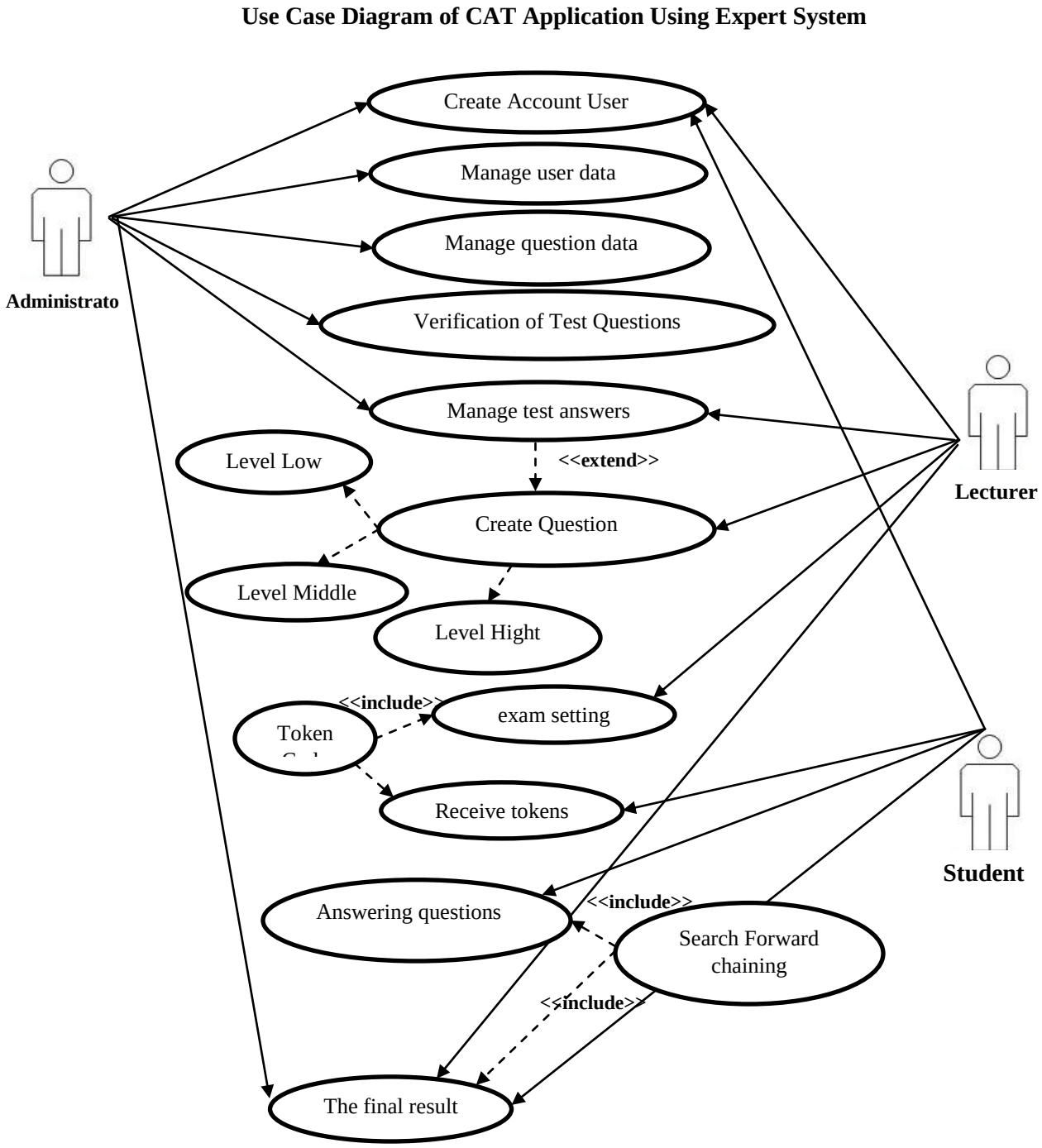

Figure 4. Use case diagram

3.3. Database Design

The database used in the CAT application uses an Expert System, namely Structure Query Language (SQL). Where the database can be accessed from the database server using SQL. The relationship between one table and another in the form of the primary key and guest key for each table is illustrated in Figure 5 using a class diagram.

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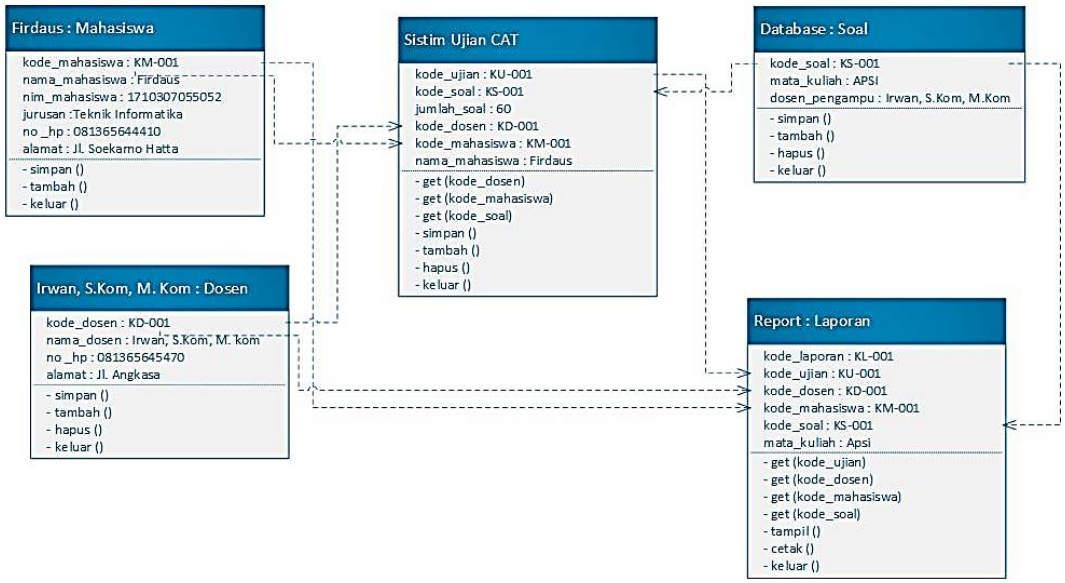

Figure 5. Class Diagram

3.3. The CAT Aplication Using Expert System

CAT applications using the Expert System consist of data input displays and output displays in the form of solutions. Input display is a form to enter data on activities carried out by the object and subject concerned. The input display functions as a dialog interface between the application and the user. The initial display of the CAT application using the Expert System is a user interface to be able to log into the CAT application which is illustrated in Figure 6.

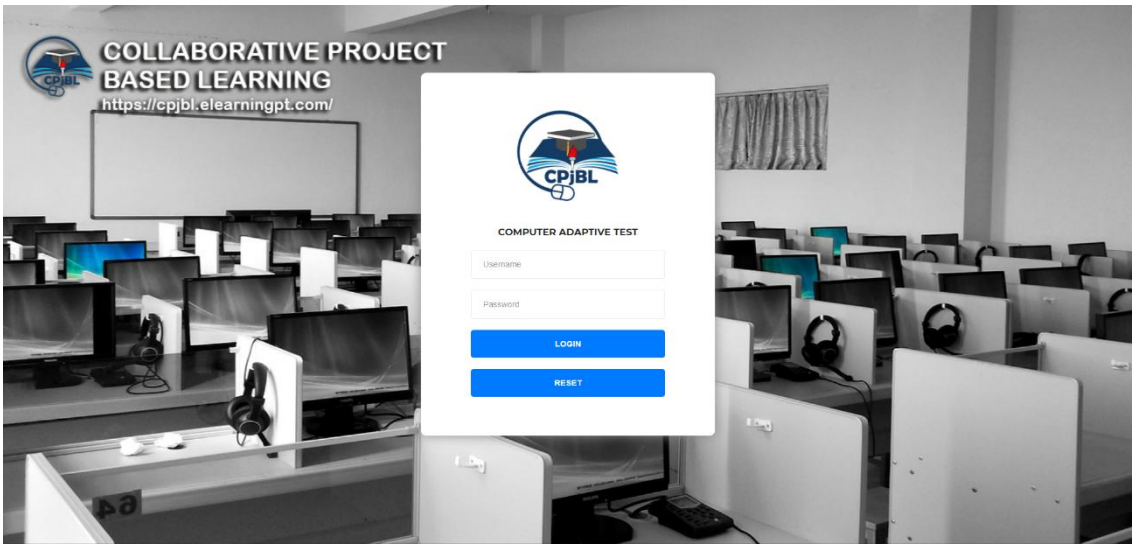

Figure 6. CAT Application Login Page Display

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After the user logs into the CAT application using an expert system then the application directs the user to the administrator's main page view, the lecturer form display, the student form display, the question bank view, the test start display, the test answer display and the test result display illustrated from Figure 7 to figure 14.

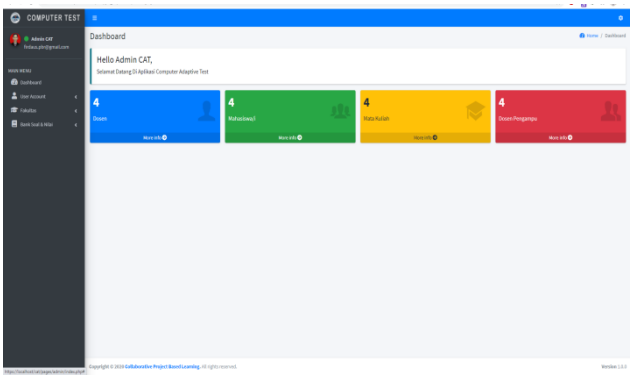

Figure 7. The Administrator's Main Page View

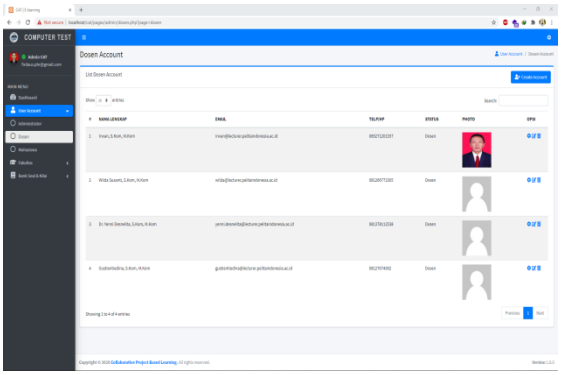

Figure 8. The Display of Lecturer View

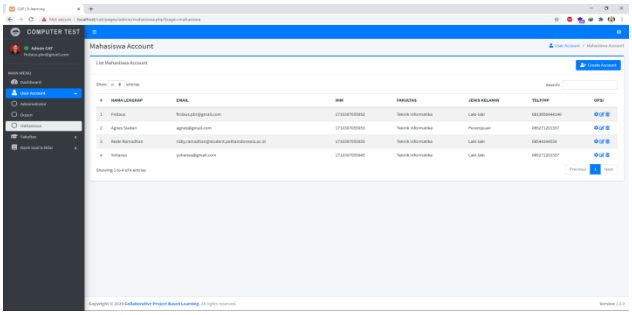

Figure 9. The Display of Student Form

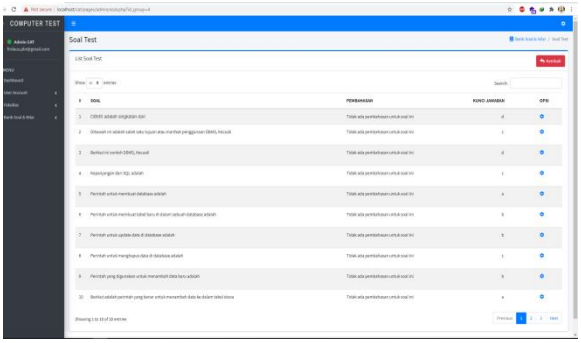

Figure 10. The Display of Question Form

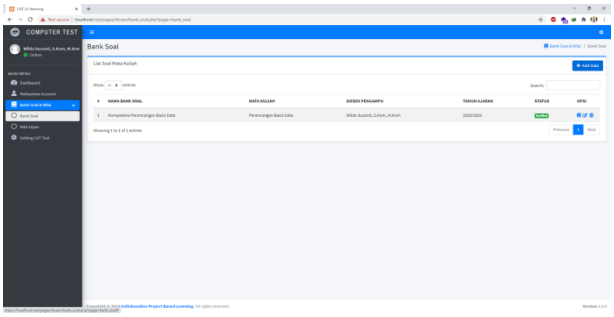

Figure 11. The Display of Question Bank

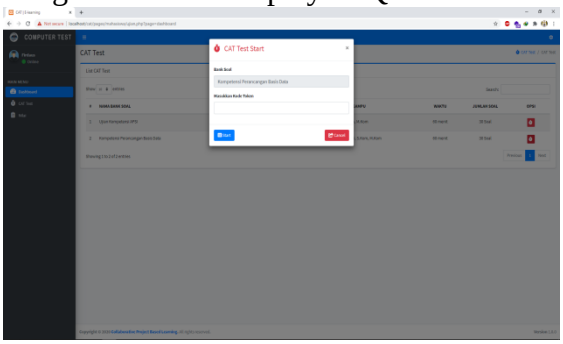

Figure 12. The Display of Start Test

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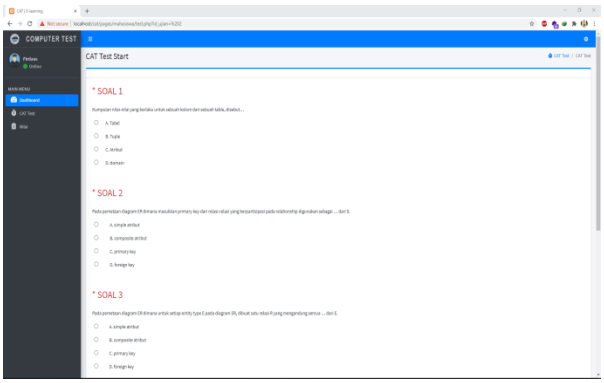

Figure 13. The Display of Answering Questions

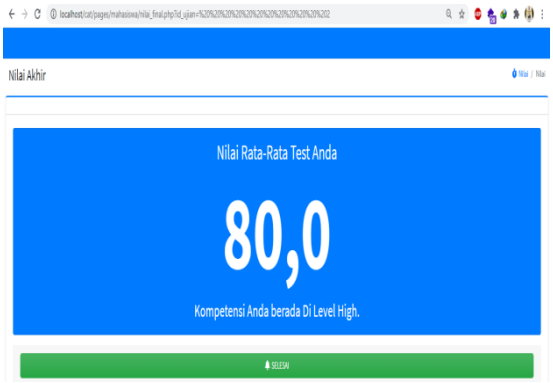

Figure 14. The Display of Test Result

4. Conclusion

The CAT application using an expert system in e-learning can trace the items given based on the level of difficulty in accordance with the response of student answers in the application. Inference System with forward chaining is able to arrange and select items and measure the ability of students with high, medium and low difficulty levels. So that students with low abilities will get items with a low level of difficulty, as well as students with high abilities will get items at high level. With the Computer Adaptive Test (CAT) application using an expert system, lecturers can find out the abilities of the students they are teaching, so that lecturers can take appropriate action in conducting lectures.

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